AMERICAN POLAR SOCIETY
75th Anniversary
MEETING and SYMPOSIUM

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THE POLAR REGIONS IN THE 21ST CENTURY:
Globalization, Climate Change and Geopolitics

15-18 April 2013

Marine Biological Laboratory

Woods Hole, Massachusetts

A Tribute

Malcolm W. Browne

Malcolm Browne served as president of the American Polar Society during the challenging transitional years after August Howard passed away. I recall especially the critical role he played in recruiting Capt. Brian Shoemaker to become the new secretary of the Society, which revitalized the organization not only with new issues of *The Polar Times* but with a series of important symposia.

Having distinguished himself as science writer for *The New York Times*, it seems appropriate that some recognition of Malcolm Brown's service to the Society be made at our symposium at the Marine Biological Laboratory in 2013.

Malcolm passed away 27 August 2012.

— Dr. Richard Chappell

Malcolm Browne's obituary appears online in *The New York Times*: http://www.nytimes.com/2012/08/29/world/asia/malcolm-w-browne-pulitzer-winner-dies-at-81.html

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Over one hundred years ago, the world turned its attention to the Polar regions, wondering what was there. Today, the world is concerned about the environmental changes that are occurring in those same locations. Global economic affiliations and geopolitics in the 21st century will be directly affected and perhaps driven by the climate and sea-ice changes tracked by contemporary polar science.

For 75 years, the American Polar Society has both documented and communicated polar activities to the interested world. The 2013 75th Anniversary of *The Polar Times* and the meeting and symposium of the American Polar Society will bring together the current leaders in science, government, commerce, and diplomacy for a state-of-the-art forecast of the next 75 years—in a world influenced more than ever before by the destiny of the Arctic and Antarctic.

MONDAY, April 15

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REGISTRATION ..... 2 – 10 p.m.
DINNER and WELCOME ..... 5:30 – 7 p.m.
RECEPTION (Mixer; Full Bar) ..... 7 – 9 p.m.

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TUESDAY, April 16

PRE-SESSION REGISTRATION ..... 7:30 – 8:30 a.m.

WELCOME and INTRODUCTION ..... 8:30 – 8:45 a.m.

Captain Alfred McLaren, USN (Ret.), Ph.D. , President, American Polar Society—Under-ice Arctic submarine captain, research scientist, former president of the Explorers Club.

KEYNOTE SPEAKERS

Contrary to tradition, APS has elected to engage and honor two keynote speakers: Dr. Lonnie Thompson and Dr. Paul Andrew Mayewski. Respectively, each holds exceptional expertise in the earth's geophysical changes and the effect of climate change on the living world. These two complementary themes form the foundation and balance for the 75th Anniversary Symposium.

1. **Earth's Climate History, from Mountain Glaciers and Ice Cores**
[with introduction by Dr. Mark Bowen] ..... 8:45 – 9:45 a.m.

Dr. Lonnie Thompson, **Distinguished Professor in the School of Earth Sciences**—Research Scientist, Byrd Polar Research Center, Ohio State University. Recipient of numerous international awards including the National Medal of Science.

BREAK ..... 9:45 – 10:15 a.m.

2. **Journey Into Climate Change — Challenges, Predictions and Opportunities** [with introduction by Capt. Alfred McLaren]..... **10:15 – 11:15 a.m.**

Dr. Paul Andrew Mayewski, **Director and Distinguished University Professor, Climate Change Institute, University of Maine**—Expert in climate science and glaciology and recipient of numerous international awards in science and exploration.

LUNCH.....**11:45 a.m. – 1 p.m.**

BOOK SIGNING..... **12:30 – 1:30 p.m.**

3. **Trends in Accumulating Greenhouse Gases and Their Influences on the Earth's Climate**..... **1:30 – 2:30 p.m.**

Dr. Susan Solomon, **Ellen Swallow Richards Professor of Atmospheric Chemistry and Climate Science, MIT**—Leader on the Intergovernmental Panel on Climate Change (IPCC, 2007), which jointly won, with Al Gore, the Nobel Peace Prize. Recipient of numerous international awards including the National Medal of Science. An APS Luminary.

4. **The Earth's Disappearing Cryosphere: Glaciers, Snow Cover, Floating Ice and Permafrost**..... **2:30 – 3:30 p.m.**

Dr. Richard S. Williams, Jr., **Adjunct Senior Scientist, Woods Hole Research Center, Woods Hole, Massachusetts**—Geologist, glaciologist, and satellite remote sensing expert. Editor of 11-volume *Satellite Image Atlas of Glaciers of the World* series.

BREAK ..... **3:30 – 4 p.m.**

5. **Eyewitness to Global Warming** ..... **4 – 5 p.m.**

Mr. Will Steger, **The Will Steger Foundation**—Advocate for the polar environment and pioneer in adventure-based environmental education. Recognized by numerous leading international organizations. An APS Luminary.

MIXER—Beer/Wine ..... **5 – 7 p.m.**

DINNER/BANQUET – Lobster Boil ..... **7 – 9 p.m.**

Welcome by Capt. Alfred McLaren

BANQUET SPEAKER

Dr. David Gallo, **Director of Special Projects, Woods Hole Oceanographic Institution**—Topic to be determined, but will be drawn from his exciting involvement with numerous projects including Climate Change; Origins, Evolution, and Destiny—Clues from the Deepest Sea; and Marine Archeology, in a search for a ship that every Antarctic historian is familiar with — a talk not to be missed!

AWARDS and PRESENTATIONS

WEDNESDAY, April 17

6. **The New Maritime Arctic: Global Challenges & Opportunities** ..... **8:15 – 9:15 a.m.**

Dr. Lawson Brigham, **Distinguished Professor, University of Alaska Fairbanks**—Chair of the Arctic Council's Arctic Marine Shipping Assessment and expert on Arctic marine policy, the Arctic Council, and geopolitics of the Arctic.

7. **Fitting Together the Political Pieces: Regional Cooperation in Antarctica and the Arctic** ..... **9:15 – 10:15 a.m.**

Mr. Tucker Scully, **representative to the Antarctic Treaty Summit**—Former Director, Office of Ocean Affairs, U.S. Department of State. Expert on the Antarctic Treaty and the Arctic Council.

BREAK ..... **10:15 – 10:30 a.m.**

8. **Exploring the Extended Continental Shelf off Alaska: Implications and Importance to the U.S.** ..... **10:30 – 11:30 a.m.**

Dr. Deborah Hutchinson, **Marine Geologist, U.S. Geological Survey, Coastal and Marine Geology**—Leader of USGS Law of the Sea Studies, to conduct scientific studies beyond 200 nautical miles in support of understanding the location of the Extended Continental Shelf of the U.S. and island trust territories.

9. **Global Climate and Policy Impacts of Thawing Permafrost** ..... **11:30 a.m. – 12:30 p.m.**

Dr. Kevin Schaefer, **University of Colorado, CIRES**—Principal Investigator of the first study to estimate and assess the impacts of worldwide carbon release from thawing permafrost.

LUNCH ..... **12:30 – 1:30 p.m.**

COMMEMORATION PRESENTATION

August Howard, an executive with National Council of Boy Scouts of America, founded The American Polar Society in 1934 and *The Polar Times* in 1935. Mr. Howard developed a passionate interest in the polar regions, beginning with Admiral Richard E. Byrd's First Antarctic Expedition (1928-1930). Commemorating Mr. Howard's passion, Admiral Byrd's grandson, Mr. Bob Byrd Breyer, will offer a selected history of Admiral Byrd's First Expedition. (The new anniversary issue of *The Polar Times—Seven Decades and Seven Years of Service to the Polar Community*—expands upon this important part of polar history.)

10. **Admiral Byrd's First Expedition (BAE I), the Fate of the Crashed Fokker Aircraft, and Current Plans for Recovery** ..... **1:30 – 2:15 p.m.**

Mr. Bob Byrd Breyer, **grandson of Admiral Richard E. Byrd**—This special presentation features black-and-white clips of Admiral Byrd's first Antarctic expedition of 1928-30, revealing not only events that preceded the beginning of the American Polar Society and production of *The Polar Times* in 1935, but also a view to the future.

BREAK ..... **2:15 – 2:45 p.m.**

11. **PANEL—The Next 75 Years: The Influence of the Poles on the Earth of Tomorrow** ..... **2:45 – 4 p.m.**

Dr. Lawson Brigham, University of Alaska Fairbanks (Maritime Issues)

Mr. Tucker Scully, U.S. Department of State (Geopolitics)

Dr. Kevin Schaefer, University of Colorado (Environmental Issues)

QUESTION and ANSWER PERIOD

ADJOURNMENT and FINAL WORDS

MIXER: BEER/WINE and RECEPTION ..... **5 – 7 p.m.**

ADDITIONAL NOTES TO THE SYMPOSIUM

MONDAY, April 15, 2013: Arrival is expected for most attendees.

- Dinner and a Mixer will be offered by the Marine Biological Laboratory, along with Registration.
- Registration, housing and main meals are provided at the Swope Center. The presentations and the breaks will be in the Speck Auditorium in Rowe Building, very close to the Swope Center.

TUESDAY, April 16: Breakfast will be offered from 7:00 to 8:30 a.m.

- Registration will again be offered from 7:30 to 8:30 a.m. The Introductory Session, with Capt. Alfred McLaren, begins at 8:30 a.m.

WEDNESDAY, April 17: Breakfast will be served from 7 to 8:30 a.m.

- The first session, with Dr. Lawson Brigham, will begin at 8:15 a.m.

THURSDAY, April 18: Departure is expected for most attendees.

- Breakfast will be served from 7 – 8:30 a.m.

ABSTRACTS

Admiral Byrd's First Antarctic Expedition, the Fate of the Fokker Aircraft, and Plans for Recovery

Bob Byrd Breyer
bobbyrdbreyer@aol.com

The Antarctic expedition of Admiral Richard Evelyn Byrd in 1929-31 was famous for a number of reasons – it was the first of several that Admiral Byrd led for several decades; the introduction of the airplane to extend exploration of the continent to the interior; and the first aircraft to reach the South Pole in an overflight on 29 November 1929 and return to base at Little America. A geologic field party in the Rockefeller Mountains had the use of a Fokker Super Universal Monoplane for transport, and although it was secured properly, a severe storm wrecked the plane and carried it for about a mile and deposited it on an ice-covered lake, where the wreck lies today. Bob Byrd Breyer heads the Byrd Aircraft Recovery Expedition with intentions to visit the site and return the frame of the aircraft to the U.S. for display in a museum.

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The New Maritime Arctic: Global Challenges and Connections

Lawson W. Brigham, PhD
University of Alaska Fairbanks

Early in the 21st century the maritime Arctic is experiencing unprecedented and rapid change. Globalization, regional climate change and geopolitics are driving significant changes in this once remote, marine region at the top of the world. The Arctic is understood to be a large storehouse of untapped natural resources, and exploration and development are accelerating to where the region is set to be a player in the global economy. Marine access is also changing in response to a profound transformation of Arctic sea ice. These increases in Arctic marine access present complex challenges to the existing legal and regulatory structures that address marine environmental protection and marine safety. Unique challenges are also provided by the ongoing process under the United Nations Convention on the Law of the Sea (UNCLOS) for delimitation of the outer continental shelf in the Arctic Ocean (as well as throughout the global oceans). In the midst of these changes, the Arctic Council, an intergovernmental forum of the eight Arctic states, has focused its efforts on environmental protection and sustainable development issues. The Council conducted an Arctic Marine Shipping Assessment during 2005-09 which established a framework for addressing the protection of Arctic people and the marine environment in response to growing use of Arctic waterways. There is little doubt all of these new economic connections and environmental challenges will require historic levels of cooperation among the Arctic states, and most importantly, engagement of the entire Arctic community with the rest of the globe.

Exploring the Extended Continental Shelf Off Alaska: Implications and Importance to the U.S.

Deborah Hutchinson
U.S. Geological Survey
Woods Hole, Massachusetts

The Arctic Ocean north of Alaska is one of the least explored ocean basins on Earth because of its remoteness and perennial ice cover. Its area is huge and few surface ships venture deep into the ice alone. In 2008, the U.S. and Canada began the first of four two-icebreaker expeditions into this far north region to jointly map the extended continental shelf (ECS) of our respective nations. The U.S. flagship icebreaker USCGC *Healy* broke ice ahead of the Canadian flagship icebreaker CCGS *Louis S. St-Laurent* (*Louis*) to collect seismic data; *Louis* broke ice ahead of *Healy* in the heaviest ice conditions to collect multibeam bathymetric data. Jointly, the expeditions acquired more than 15,000 km of seismic, multibeam, and other geophysical data. Numerous other experiments utilized the ships to collect data from within the ice to study, for example, ocean acidification, physical oceanography, meteorology, and noise in the oceans. In 2011, scientific applications for using autonomous underwater vehicles and unmanned aerial vehicles in ice-covered regions were tested.

The purpose of the two-icebreaker expeditions was to identify the outer limits of the ECS, which is that portion of submerged land beyond 200 nautical miles that, after satisfying criteria in Article 76 of the Convention on the Law of the Sea, a nation can utilize, manage, or conserve, similar to submerged land within 200 nautical miles. The U.S. Arctic ECS extends from 200 to as much as an additional 600 nautical miles north of Alaska, and may include an area as large as 500,000 km2 (somewhat larger than the size of California). Energy and mineral wealth in this region remains poorly known and uncertain because of lack of data.

The greatest challenges in collecting ship-board data in ice-covered regions are designing systems to minimize damage from the cold and ice, repairing instrumentation from more frequent failures, and contingency planning for variable ice conditions. The scientific benefits, however, have been outstanding, with a high-quality dataset that is providing revised interpretations of the geologic opening of the basin, the nature and thickness of the sedimentary section, and a new understanding of the processes controlling sediment deposition.

Journey Into Climate: Challenges, Realities, Predictions and Opportunities

Paul Andrew Mayewski
Climate Change Institute
University of Maine

Ice core records offer continuous, high resolution, multi-parameter contamination-free measurements of soluble ions, trace elements, stable isotopes, gases, organic acids, radionuclides and microparticles [for an overview see (1)]. These measurements provide reconstructions of past temperature, precipitation, storminess, sea ice extent, biological productivity, volcanic activity, biomass burning and more that can be directly calibrated with other paleoclimate records, historical records and instrumented series of temperature,

precipitation, surface pressure, and sea ice extent resulting in dramatic realizations of climate change on timescales covering the last >100,000 years and sub-annually resolved, continental-scale frameworks to understand climate change over the last few centuries employing a global array of ice cores recovered by the Climate Change Institute from sites throughout Antarctica, the Arctic, Asia, South America, and more [for an overview see (2)].

Ice core contributions to society have revolutionized the understanding of climate change by: characterizing the role of multiple forcing on climate; identifying and exploring the significance of abrupt natural climate change events and potential for future abrupt changes in climate; detecting and documenting human-source pollution in the atmosphere as a basis for assessing the current health of the atmosphere [see (3) for an application]; exploring changes in the behavior of major atmospheric circulation systems such as the Icelandic and Amundsen Sea Lows, Siberian and Bolivian Highs and El Niño/Southern Oscillation; and defining changes in civilization resulting from climate change [see (2) and (4) for books written for the public on these topics by Mayewski].

The Climate Change Institute has a vision for the future of climate research that includes: completion of a global array of ice cores before many of these records are destroyed by warming; interactive climate data archives employing our newly developed cyberinfrastructure tools; cutting edge innovations in analysis that have now increased sample resolution from 100 samples per meter to 100,000 samples per meter; combining instrumentally calibrated ice core records with existing high resolution climate reanalysis and new innovations in regional scale climate modeling; and unique graduate education opportunities [see (5) and (6)].

(1) http://climatechange.umaine.edu/icecores/IceCore/Home.html

(2) http://journeyintoclimate.com/dl/JICBrochure.html

(3) http://10green.org/

(4) http://www.amazon.com/The-Ice-Chronicles-ebook/dp

(5) http://climatechange.umaine.edu/research/expeditions

(6) http://a2c2igert.umaine.edu/

Global Climate and Policy Impacts of Thawing Permafrost

Dr. Kevin Schaefer

National Snow and Ice Data Center

449 UCB, University of Colorado, Boulder, CO 80309-0449

kevin.schaefer@nsidc.org

The Permafrost Carbon Feedback is an amplification of warming from the burning of fossil fuels due to carbon dioxide and methane emissions from thawing permafrost. Arctic permafrost currently contains ~1700 Gigatons of carbon in the form of frozen organic matter, roughly double the amount of carbon currently in the atmosphere. This organic matter has been frozen in permafrost since the last ice age and will remain there as long as the permafrost does not thaw. However, as temperatures increase due to climate change, some permafrost will thaw out and the organic matter will decay, releasing carbon dioxide and methane into

the atmosphere. Emissions from thawing permafrost will amplify warming due to the burning of fossil fuels, initiating the Permafrost Carbon Feedback and accelerating the rate of global climate change. We estimate that thawing permafrost will emit 190±64 Gt of carbon into the atmosphere by 2200, potentially increasing atmospheric carbon dioxide concentrations by 87±29 ppm. The contribution of the Permafrost Carbon Feedback to overall global warming is proportional to the fraction of total emissions that come from thawing permafrost, or an additional 10-20% of warming. The global treaty to reduce fossil fuel emissions must account for emissions from thawing permafrost or we risk overshooting our target carbon dioxide concentration and end up with a warmer climate than planned. Negotiations currently focus on a global warming target of 2°C above pre-industrial temperatures. Here we describe the Permafrost Carbon Feedback, how the organic matter became frozen in the permafrost, how much will thaw out in the future, and what this means for global climate and policy.

Fitting Together The Political Pieces: Regional Cooperation in Antarctica and the Arctic

R. Tucker Scully
1517 P Street, N.W., Apt.3
Washington, D.C. 20005

Multilateral polar cooperation has been shaped by the world that emerged from the Second World War. As that world is being fundamentally altered, polar institutions face new and daunting challenges.

Region-wide polar cooperation emerged first in Antarctica. The Antarctic Treaty of 1959 guarantees freedom of scientific research in Antarctica and establishes the area as a zone of peace where military activities, nuclear explosions and the disposal of radioactive waste are prohibited. It defused territorial disputes and Cold War tensions that threatened actual conflict. The Treaty has evolved into a system of governance, addressing all human activities in Antarctica, including establishing an ecosystem-based management regime for fisheries and banning mineral resource development.

Arctic cooperation, by contrast, was hostage to the Cold War until perestroika and the break-up of the Soviet Union. The 1991 Arctic Environmental Protection Strategy (AEPS) represented the first intergovernmental cooperative effort among the eight Arctic nations. Agreement on the Arctic Council followed in 1996. The Council, a high level forum, promotes cooperation among the Arctic States, with full involvement of Arctic indigenous peoples; incorporates the programs established under the AEPS; and adds a sustainable development program. The Council has been a catalyst in identifying priority issues, particularly climate change and its impacts in the Arctic, and is evolving a more formal structure with the conclusion of a legally binding Arctic search and rescue agreement and establishment of a permanent secretariat.

Accelerating climate change and demand for resources raise management issues of a complexity and magnitude beyond those heretofore dealt with by polar institutions. These forces will further impact resource development, marine transportation and maritime boundaries in the polar regions, as well as regional institutions, and have fueled speculation over possible resource wars or other forms of conflict. However, the legal bases for addressing anticipated activities exist in global mechanisms such as the Law of the Sea Convention and the International Maritime Organization or in the example of the Antarctic Treaty system.

The more important issue is whether, in the face of new and expanded activities, we can adequately manage polar ecosystems and take measures best designed to preserve their functioning, including their role in supporting human communities. This will require that we devise collective means to understand polar ecosystems, how they respond to change and to distinguish between change driven by human activities directly (e.g., resource activities) and environmental change (e.g., climate change).

The Trends in Accumulating Greenhouse Gases and Their Influences on The Earth's Climate

Susan Solomon

Department of Earth Atmospheric and Planetary Sciences, MIT
Cambridge, MA 02139

Emissions of a broad range of greenhouse gases of varying lifetimes contribute to global climate change. Ice core records from Antarctica and Greenland now document the history of key greenhouse gases over time scales of nearly a million years. Recent research has been directly not only at obtaining and developing these remarkable time series, but also at understanding the sources of the gases as well as their impacts on current climate change. The data show that we have entered a new "Anthropocene" era in geologic history in which the human influence on atmospheric composition is profound. A spirited scientific discussion has taken place on exactly when the Anthropocene began, including the possible influences of early agriculture many hundreds of years ago. The severity of human-induced climate change related to the increases in greenhouse gases depends not only on the magnitude of the change but also on the potential for irreversibility.

Recent studies have shown that carbon dioxide displays exceptional persistence that renders its warming nearly irreversible for more than a thousand years after human emissions stop. Following cessation of emissions, removal of atmospheric carbon dioxide decreases radiative forcing, but is largely compensated by slower loss of heat to the ocean, so that atmospheric temperatures do not drop significantly for at least 1,000 years. Among illustrative irreversible impacts that should be expected if atmospheric carbon dioxide concentrations increase from current levels near 390 parts per million by volume (ppmv) to a peak of 450 – 600 ppmv over the coming century are irreversible dry-season rainfall reductions in several regions comparable to those of the "dust bowl" era and inexorable sea level rise. The warming due to anthropogenic methane or nitrous oxide, although not irreversible, also persists notably longer than the changes in the greenhouse gas concentrations themselves. This occurs because the persistence of warming depends not just on the decay of a given greenhouse gas concentration but also on climate system behavior, particularly the timescales of heat transfer linked to the ocean. Approaches to climate change mitigation options through reduction of green-house gas or aerosol emissions therefore should not be expected to decrease climate change impacts as rapidly as the gas or aerosol lifetime, even for short-lived species; such actions can have their greatest effect if undertaken soon enough to avoid transfer of heat to the deep ocean.

Eyewitness to Global Warming

Will Steger
The Will Steger Foundation

Will Steger, world renowned polar explorer, educator, photographer, writer and lecturer will present a retrospective of a life in the arctic regions of the world. He has logged thousands of miles of travel by dogsled and has become a voice calling for understanding and the preservation of the arctic. The presentation "Eyewitness to Global Warming," is his vivid account of the changes that he's witnessed firsthand, caused by global warming pollutants, in Arctic regions over four decades of polar exploration. Steger shares stunning photographs from his expeditions along with compelling data and satellite imagery to document the deterioration in the polar ice caps. While the issue is critical, and the presentation is dramatic, Steger's message is one of hope and empowerment. An understanding of our role in the causes and effects of global warming make this personal. But as Steger explains, solutions are readily available and by making economically and environmentally smart choices people can make a difference.

Earth's Climate History from Mountain Glaciers and Ice Cores

Lonnie G. Thompson
Byrd Polar Research Center
School of Earth Sciences, The Ohio State University
Columbus, OH 43210

Glaciers serve both as recorders and early indicators of climate change. Over the past 35 years our research team has recovered climatic and environmental histories from ice cores drilled in both Polar Regions and from low to mid-latitude, high-elevation ice fields. Those ice core–derived proxy records extending back 25,000 years have made it possible to compare glacial stage conditions in the Tropics with those in the Polar Regions. High-resolution records of $\delta 18O$ (in part a temperature proxy) demonstrate that the current warming at high elevations in the mid- to lower latitudes is unprecedented for the last two millennia, although at many sites the early Holocene was warmer than today. Remarkable similarities between changes in the highland and coastal cultures of Peru and regional climate variability, especially precipitation, imply a strong connection between prehistoric human activities and regional climate. Ice cores retrieved from shrinking glaciers around the world confirm their continuous existence for periods ranging from hundreds to thousands of years, suggesting that current climatological conditions in those regions today are different from those under which these ice fields originated and have been sustained.

The current warming is therefore unusual when viewed from both the millennial-scale perspective provided by multiple lines of proxy evidence and the 160-year record of direct temperature measurements. The ongoing widespread melting of high-elevation glaciers and ice caps, particularly in low to middle latitudes, provides strong evidence that a large-scale, pervasive and, in some cases, rapid change in Earth's climate system is underway. Observations of glacier shrinkage during the 20th and 21st centuries girdle the globe from the South American Andes, the Himalayas, Kilimanjaro (Tanzania, Africa) and glaciers near Puncak Jaya,

Indonesia (New Guinea). The history and fate of these ice caps, told through the adventure, beauty and the scientific evidence from some of world's most remote mountain tops, provide a global perspective for contemporary climate changes.

The Earth's Disappearing Cryosphere: Glaciers, Snow Cover, Floating Ice, and Permafrost

Richard S. Williams, Jr.
Woods Hole Research Center
geoinfo@comcast.net

Since the late 1960s and early 1970s, when Earth-orbiting satellites equipped with imaging and non-imaging sensors first began to systematically record changes in the Earth System, scientists from many nations have been analyzing the changes on the planet's surface, including the cryosphere. A 40-year record of satellite data indicates that the Earth's cryosphere, glaciers, snow cover, and floating ice (sea ice and lake ice and river ice) have been reduced in area, and significantly so since the mid-1990s. Regions underlain by permafrost have also been changing, but monitoring of those significant changes has been from direct field measurements.

The warming of the Earth's global climate is being driven by the increase in carbon dioxide (CO2) and other greenhouse gases [e.g., methane (CH4), etc.] in the Earth's atmosphere, the result of widespread deforestation and burning of fossil fuels. In May 2012, a CO2-monitoring station in Iceland measured 400 ppmv! Global climate warming is causing accelerated melting of the Earth's cryosphere, especially in the polar and high-mountain regions.

An overview of the current status of the Earth's cryosphere will be presented, with conclusions about the impact of the loss of ice. The shrinkage of glaciers reduces water supplies in the Himalaya and Andes, hydroelectric-power generation in Europe and other regions, and contributes more than 50 percent of the rise in sea level (about 4 mm a-1 at present), a global glaciological hazard. The reduction in snow cover reduces seasonal soil moisture and recharge of ground-water reservoirs. The reduction in area and thickness of sea ice will soon permit regular seasonal shipping in the Arctic Ocean; also changing the albedo of the ocean surface adding to warming of the region. The loss of permafrost poses major engineering challenges and releases sequestered CH4 from the continental shelves and land, thus enhancing the greenhouse-gas effect.

In the coming decades of the 21st century, it is postulated that more and more of the Earth's cryosphere will disappear (melt away). The major impacts on the Earth System will be an accelerated rise in global sea level, thereby slowly and relentlessly inundating low-lying coastal regions and islands; development of seasonal shipping through the Arctic Ocean and infrastructure to support it; and release of CH4 from permafrost, adding to the concentration of greenhouse gases in the Earth's atmosphere.

BIOGRAPHIES

Bob Byrd Breyer

Byrd Aircraft Recovery Expedition

Bob Byrd Breyer is the son of Katharine Byrd Breyer, daughter of Admiral and Mrs. Richard E. Byrd. Breyer grew up in Los Angeles and earned BS (Business) and MBA degrees from USC. He was an Eagle Scout and has gained extensive hiking, backpacking and mountaineering experience from Switzerland to New Zealand and many places in between. In 1973 he was part of the construction team that built the dome structure at Amundsen-Scott South Pole Station. He traveled to the South Pole twice and was promoted to construction camp manager. In November 1979, Breyer was invited by the National Science Foundation to return to the South Pole for a third time as a representative of the Byrd family, to commemorate the 50th anniversary of his grandfather's flight to the Pole in 1929.

Currently Breyer is president of the Byrd Aircraft Recovery Expedition, a non-profit incorporated for the specific purpose of recovering one of Admiral Byrd's airplanes from Antarctica and returning it to the States for display in a museum. The airplane is a Fokker Super Universal monoplane and was wrecked in a storm in March 1929 in the Rockefeller Mountains in Byrd's first Antarctic Expedition. The frame of the aircraft is accessible, sitting on a frozen lake. By recovering and displaying the Fokker the Byrd Aircraft Recovery Expedition seeks to educate Americans about Antarctica; Admiral Byrd, the last of the great explorers; and the Antarctic Treaty.

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Dr. Lawson W. Brigham

University of Alaska Fairbanks

Dr. Lawson W. Brigham is Distinguished Professor of Geography & Arctic Policy at the University of Alaska Fairbanks. During 2005-2009 he was chair of the Arctic Council's Arctic Marine Shipping Assessment and Vice Chair of the Council's working group on Protection of the Arctic Marine Environment. Dr. Brigham was a career U.S. Coast Guard officer, serving from 1970-95 and retiring with the rank of Captain. He commanded four Coast Guard cutters including the patrol cutter *Point Steele*, Great Lakes icebreaker *Mobile Bay*, the medium endurance cutter *Escanaba* and the polar icebreaker *Polar Sea*; he also served as Chief of Strategic Planning at Coast Guard Headquarters. He has participated in more than 15 Arctic and Antarctic expeditions and, during summer 1994, *Polar Sea* crossed the Arctic Ocean for science with the Canadian Coast Guard icebreaker *Louis S. St-Laurent*.

Dr. Brigham has been a research fellow at Woods Hole Oceanographic Institution, a faculty member of the U.S. Coast Guard Academy and the Naval Postgraduate School, and Alaska Office Director of the U.S. Arctic Research Commission. He is a graduate of the U.S. Coast Guard Academy (BS), a distinguished graduate of the U.S. Naval War College, and holds graduate degrees from Rensselaer Polytechnic Institute (MS) and the University of Cambridge (MPhil and PhD). His research interests have focused on the Russian maritime Arctic, Arctic climate change, marine transportation, Arctic futures, remote sensing of sea ice, and polar geopolitics. Captain Brigham was a 2008 signer of the American Geographical Society's Flier's and Explorer's Globe, the Society's historic globe of exploration. This signing was in recognition of *Polar Sea*'s 1994 voyages and the ship becoming the first in history to reach the extreme ends of the global ocean. Dr. Brigham was named the 2010 Distinguished Alumnus of the U.S. Coast Guard Academy and currently serves as a member of NOAA's federal Hydrographic Services Review Panel.

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Mark Bowen

Mark Bowen's three main interests of writing, climbing and science have served him well in his career. A Ph.D. in Physics from MIT is part of his credentials, but the three interests mentioned all came together in 1997 when he went to the highest mountain in Bolivia on an assignment to write

an article about Lonnie Thompson, who was drilling ice cores on the mountain's summit at the time. The experience left him with a message in his life that pointed out the importance of global warming. Following the writing of the article, he spent some years researching and writing a book about Thompson, joining him on ice-drilling expeditions to Mt. Kilimanjaro. The book, *Thin Ice: Unlocking the Secrets of Climate in the World's Highest Mountains*, was published in 2005 and represents a documentary of the life of a dedicated scientist who is one of the world's leading paleoclimatologists.

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David G. Gallo

Woods Hole Oceanographic Institution

David G. Gallo, Ph.D. is Director of Special Projects at the Woods Hole Oceanographic Institution.

Dr. Gallo received a B.Sc. and M. Sc. degree in Geological Science from the State University of New York at Albany and a Ph.D. in Oceanography from the University of Rhode Island. In 1987 he was invited by Dr. Robert Ballard (discoverer of the wreck of RMS *Titanic*) to join his team at the Woods Hole Oceanographic Institution as the Assistant Director of the Center for Marine Exploration.

In Dr. Gallo's present role, he works closely with scientists and engineers at the forefront of global exploration and discovery. He has participated in numerous expeditions to the Atlantic, Pacific and Indian Oceans, and to the Mediterranean Sea. He was one of the first oceanographers to use a combination of submarines and robots to map the undersea world. He was a participant during an exploration of RMS *Titanic* and the German battleship *Bismarck* using the Russian MIR submarines and a participant in a recent expedition to find the lost WWII submarine USS *Grunion*.

In addition to ocean exploration, Dr. Gallo is currently interested in understanding the relationship between humanity and the sea. He was closely involved in the formulation and development of the Liquid Jungle Laboratory of Panama, a venture designed to better understand the interaction between people, tropical forests and coastal marine habitats.

Dr. Gallo is passionate about exploration and discovery and dedicated to communicating the importance of science and engineering to the public-at-large. He maintains close working relationships with scientists, filmmakers and media broadcasters (Discovery Channel, History Channel, National Geographic and PBS). He was instrumental in the development of the "Jason Project" and is presently involved with the FIRST Robotics Competition and with the National Underwater Robotics Competition.

Dr. David Gallo has lectured extensively, both nationally and internationally, to audiences ranging from elementary school children through CEOs and has participated in numerous television and radio broadcasts.

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Deborah Hutchinson

U.S. Geological Survey
Woods Hole, Mass.

Deborah Hutchinson has been a research geologist with the U.S. Geological Survey in Woods Hole, Massachusetts, since 1974. She is a relative newcomer to Polar work, beginning a project in the Arctic in 2007 after successfully developing an agreement with the Geological Survey of Canada to work collaboratively on Law of the Sea investigations. As Project Chief for USGS Law of the Sea studies in general and lead geologist for the Arctic component, she has spent three field seasons collecting geophysical data aboard the Canadian Coast Guard Icebreaker CCGS *Louis S. St-Laurent* in the ice north of Alaska, reaching to within 90 nautical miles of the North Pole in 2011. Her previous research was on the Atlantic and Gulf of Mexico continental margins as well as in Lake Baikal, Russia. She served as Chief Scientist and Center Director of the Woods Hole Office between 1996 and 2002. She has served on USGS, DOI, and international committees to render scientific judgment. Her PhD is from the University of Rhode Island (1984).

Paul Andrew Mayewski

Climate Change Institute

University of Maine, Orono, Maine

Paul Andrew Mayewski is Director and Professor of the Climate Change Institute at the University of Maine. He is a climate scientist, glaciologist and explorer and has led more than 50 expeditions throughout the Antarctic, Arctic, Himalayas, Tibetan Plateau, Andes and Tierra del Fuego, including, in the last year, crossing more than 1,800 nautical miles of the Southern Ocean in a 73-foot sailboat and two expeditions to 20,000 feet in the central Andes. He has organized, led and been chief scientist for several highly prominent multi-disciplinary, multi-national research efforts such as the Greenland Ice Sheet Project 2 (GISP2), the International Trans-Antarctic Scientific Expeditions (ITASE), the Asian Ice Core Array (AICA), Polar-Tropical Connections (PTC) and Atmospheric Investigation Regional Mapping and Prediction (AIRMAP). His scientific findings include discovery of abrupt climate change defined by changes in the magnitude, position and frequency of atmospheric circulation systems; impact of past changes in climate on the course of human civilization; impacts of human activity on the chemistry of the atmosphere; demonstration of the interaction of multiple controls on the climate system; instrumental calibration of ice core climate proxies and development of ultra-high resolution non-destructive ice core analyses—all published in more than 350 peer-reviewed papers and several books for the public. Mayewski has received numerous honors and awards in climate science, glaciology and exploration and has appeared in several hundred public venues including multiple appearances on CBS 60 Minutes, NOVA, BBC, National Public Radio and many other worldwide media outlets.

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Captain Alfred S. McLaren, USN (Ret.), Ph.D.

President, American Polar Society

Captain Alfred Scott McLaren, USN (Ret.), Ph.D., President of The American Polar Society, is an Honorary Director and former President of The Explorers Club, and a Director and Senior Pilot of Sub Aviator Systems LLC's *Super Aviator* submersible. As a nuclear attack submarine officer, he made three Arctic expeditions: the first submerged survey of the Northwest Passage, a Baffin Bay expedition, and as Commander of USS *Queenfish* (SSN-651), a North Pole expedition that completed the first survey of the entire Siberian Continental Shelf (5,200 km). Honors include the *Société de Géographie de Paris* Medal for Polar Exploration and *La Medaille de La Ville De Paris.*

A research scientist in the role of the Polar Regions in global climate change, he has authored over 50 peer-reviewed research papers. A veteran of more than 20 Cold War missions, his awards as a submarine captain include the Distinguished Service Medal, the nation's highest peacetime award; two Legions of Merit; and four Navy Unit Citations. Currently a deep sea explorer and scientist, Captain McLaren completed dives using the Russian deep-diving MIR submersibles to R.M.S. *Titanic* in 1999 and 2003; hydrothermal vents along the Mid-Atlantic Ridge in 1999; and, during 2001, the first manned dives to the wreck of the German battleship *Bismarck* at a depth of 4,750 meters beneath the sea. He returned to *Bismarck* in 2002 to make a second dive to conduct a comprehensive high-definition (HD) filming of the wreck site. He received The Explorers Club's Lowell Thomas Medal for Ocean Exploration in 2000 and its highest award, The Explorers Club Medal, in 2012. His book, *Unknown Waters* (University of Alabama Press, 2008), was judged a "Notable Naval Book of 2008" by the U.S. Naval Institute. He is a graduate of the U.S. Naval Academy and U.S. Naval War College. He holds masters degrees from George Washington University and Cambridge University (Peterhouse), and his doctorate from the University of Colorado.

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Kevin Schaefer

University of Colorado Boulder

Kevin Schaefer studies permafrost dynamics and biosphere-atmosphere interactions at the National Snow and Ice Data Center at the University of Colorado in Boulder, Colo. Dr. Schaefer uses remote sensing, field observations and state-of-the-art computer models to assess long-term changes to Arctic ecosystems, snow cover, the global carbon cycle and permafrost. He graduated with a degree in aerospace engineering from the University of Illinois in 1984 and worked for NASA for 14 years, primarily on the Space Shuttle and Space Station. He worked for the White House for two years supporting the Council on Environmental Quality and then returned to school, obtaining a Ph.D. in atmospheric science from Colorado State University. After a two-year postdoctoral fellowship at NOAA in Boulder, Dr. Schaefer started his appointment at the National Snow and Ice Data Center in 2006. Every year, Dr. Schaefer travels to Alaska, particularly the North Slope, to gather data and collect soil samples.

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R. Tucker Scully

Former Senior Official on Oceans and Polar Issues
U.S. Department of State

R. Tucker Scully joined the United States Department of State in 1965 and, after service at U.S. embassies in Beirut (Lebanon) and Athens (Greece), returned to Washington in 1972 to begin a career-long involvement in oceans and polar matters.

During the 1980s and 1990s, he was responsible for organizing and leading United States delegations in negotiations on oceans, Arctic and Antarctic issues and for coordination of United States policy on those issues. Named to the Senior Executive Service in 1991, he became Deputy Assistant Secretary of State for Oceans and Fisheries at the Department of State in 1999.

As chief United States negotiator on polar issues, Scully headed U.S. delegations to annual meetings under the Antarctic Treaty, led U.S. negotiating efforts on the 1991 Environmental Protocol to the Antarctic Treaty and was U.S. Commissioner to the Commission for the Conservation of Antarctic Marine Living Resources. He visited Antarctica on a number of occasions as leader of U.S. Antarctic Treaty inspection teams.

Scully was also deeply involved in Arctic issues, including negotiation of the maritime boundary between the United States and the Soviet Union. He represented the U.S. in negotiations that resulted in creation of the Arctic Council—an agreement to promote regional cooperation in the Arctic—and was instrumental in the conclusion of the U.S.-Russia Treaty on polar bears in 2000.

R. Tucker Scully retired from the U.S. Department of State in October 2000. In 2009, he returned to work with the Department and served as Chair of the Thirty-Second Antarctic Treaty Consultative Meeting (ATCM XXXII) held in Baltimore, Maryland.

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Susan Solomon

Massachusetts Institute of Technology

Susan Solomon is the Ellen Swallow Richards Professor of atmospheric chemistry and climate science at the Massachusetts Institute of Technology. Prior to that, she was a scientist at NOAA in Boulder, Colorado, from 1981-2011, and an adjunct professor at the University of Colorado from 1982-2011. She is well known for having pioneered the theory explaining why the ozone hole occurs in Antarctica and obtaining some of the first chemical measurements that helped to establish the chlorofluorocarbons as its cause. She is also the author of several influential scientific papers in climate science, including one on the irreversibilities of the climate change problem. She is also the author of a popular book on Antarctic history, *The Coldest March*, selected among "2001 Books of the Year" lists of *The New*

York Times, the *Economist* (UK), and the *Independent* (UK). She received the 1999 US National Medal of Science, as well as the *Grande Medaille* (highest award of the French Academy of Sciences), the prestigious Blue Planet Prize in Japan and the Volvo Environment Prize. She is a member of the National Academy of Sciences, the French Academy of Sciences, the Royal Society, the Royal Society of Chemistry and the Acadameia Europaea. Solomon Glacier in Antarctica has been named after her. She served as co-chair of the climate science group of the Intergovernmental Panel on Climate Change (IPCC) from 2002-2007. *Time* magazine named Solomon as one of the 100 most influential people in the world in 2008.

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Will Steger

The Will Steger Foundation

A formidable voice calling for understanding and the preservation of the Arctic and the Earth, Will Steger is best known for his legendary polar exploration. He has traveled tens of thousands of miles by kayak and dogsled for more than 45 years, leading teams on some of the most significant polar expeditions in history, earning him the Lifetime Achievement award from *National Geographic Adventure* magazine in 2007. Steger led the first confirmed dogsled journey to the North Pole without resupply in 1986; the 1,600-mile south-north traverse of Greenland (the longest unsupported dogsled expedition in history) in 1988; and the first dogsled traverse of Antarctica (the historic seven-month, 3,741-mile International Trans-Antarctica Expedition) in 1989–90.

Steger has continued his commitment to education and exploration through the Will Steger Foundation. Recent expeditions have included a dynamic online component and have taken Steger and his expedition teams to Ellesmere Island and Baffin Island in Canada's High Arctic. From the front lines of global warming, Steger is inspiring, educating and empowering people around the world to take action on global warming solutions.

Steger holds a Bachelor of Science in geology, Master of Arts in education, and Honorary Doctorates from the University of St. Thomas, Westminster College, Northland College and Franklin Pierce University. He founded a winter school and developed an innovative wilderness program in Ely, Minn. Steger also established the Global Center for Environmental Education at Hamline University and the World School for Adventure Learning at the University of St. Thomas, both located in St. Paul, Minn.

Steger was the first National Geographic Explorer-in-Residence (1996). The list of his numerous awards includes the Finn Ronne Memorial Award (1997), the Lindbergh Award (2006), and the Explorers Club Lowell Thomas Award (2007).

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Lonnie G. Thompson

Distinguished University Professor, School of Earth Sciences
Senior Research Scientist, Byrd Polar Research Center

Lonnie G. Thompson is one of the world's foremost authorities on paleoclimatology and glaciology. He has led 58 expeditions during the last 35 years, conducting ice-core drilling programs in the Polar Regions as well as on tropical and subtropical ice fields in 16 countries including China, Peru, Russia, Tanzania and Papua, Indonesia (New Guinea). Thompson and his team were the first to develop lightweight solar-powered drilling equipment for the acquisition of histories from ice fields in the high Andes of Peru and on Mount Kilimanjaro in Tanzania. The results from these ice-core-derived climate histories, published in more than 200 articles, have contributed greatly toward improved understanding of Earth's climate system, both past and present. This is a prerequisite for efforts to predict future changes. Thompson's research has resulted in major revisions in the field of paleoclimatology, in particular by demonstrating how tropical regions have undergone significant climate variability, countering an earlier view that higher latitudes dominate climate change.

Thompson is a member of the National Academy of Sciences and in 2007 was awarded the U.S. National Medal of Science, the highest honor the U.S. awards to American scientists. In April 2012 he received the Benjamin Franklin Medal in Earth and Environmental Science; in September 2012, the Friendship Award; and in January 2013, the International Science and Technology Cooperation Award, both from the People's Republic of China.

He has received numerous other honors and awards. In 2005, he received the John and Alice Tyler Prize for Environmental Achievement and was selected by *Time* magazine and CNN as one of America's Best in science and medicine. His team's research has been featured in hundreds of publications for the general public, including *National Geographic* and the *National Geographic Adventure* magazines. The accomplishments by Thompson and the OSU ice core team are highlighted in a 2005 book entitled *Thin Ice: Unlocking the Secrets of Climate in the World's Highest Mountains* by Mark Bowen.

In 2006, Thompson was elected as a member of the American Philosophical Society and received the Roy Chapman Andrews Society, 2007 Distinguished Explorer Award (jointly with Ellen Mosley-Thompson). In 2008 he received the Dan David Prize (jointly with Ellen Mosley-Thompson) and the Seligman Crystal award, the highest professional award given in Glaciology. In 2009, Thompson and Ellen Mosley-Thompson received the David R. Brower Conservation Award from the American Alpine Club for outstanding service in mountain conservation. In 2009, Professor Thompson received Honorary Doctor of Science degrees from both Colgate and Northwestern universities in the U.S and in 2011 from Lancaster University in the U.K. In 2009, Thompson was elected as a foreign member of the Chinese National Academy of Sciences and received the "Mountain Hero" award from The Mountain Institute in Washington D.C.

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Richie Williams

Woods Hole Research Center

Richie Williams is an adjunct senior scientist at the Woods Hole Research Center. His other affiliations are emeritus senior research geologist at the Woods Hole Coastal and Marine Science Center, U.S. Geological Survey; Vice Chairman Emeritus, Committee for Research and Exploration, National Geographic Society; and Director-Science, Geoscience Information Services. He has B.S. and M.S. degrees from the University of Michigan and a Ph.D. degree from Pennsylvania State University, all in geology. He specializes in using airborne and satellite remote sensing technology to carry out investigations of dynamic geologic, glaciologic and geomorphologic processes. Iceland is a special interest, where he and his Icelandic colleagues have been studying changes associated with volcanic activity and glacier fluctuations for more than 45 years. He is a strong proponent of cooperative international programs that use satellite image data to monitor changes globally on the Earth's surface that result from natural processes and/or human activities. His more than 300 papers, maps, books, chapters and abstracts cover a wide range of topics including remote sensing, geologic and glaciological hazards, glaciology of Iceland, global environmental change, planetary exploration, sea-level change and natural and human history of the Earth (especially human impact on the Earth System). He is a member of the Cosmos Club and the Explorers Club, a fellow of the AAAS and the Geological Society of America, and a recipient of the Distinguished Service award by the U.S. Department of the Interior. He serves on the Board of the Leifur Eiríksson Foundation. Two glaciers in Antarctica are named for him: Williams Glacier and Williams Ice Stream.

Marine Biological Laboratory

7 MBL Street, Woods Hole, Massachusetts 02543

Marine Biological Laboratory (MBL) is an international center for research, education and training in biology, medicine, and ecology. MBL is dedicated to scientific discovery and improving the human condition through research and education. Founded in 1888, MBL is a private, nonprofit corporation with 436 members.

MBL's leading scientists are recognized authorities in the fields of ecosystem processes and climate change. More than 50 Nobel Laureates have taught, attended courses, or have done research at MBL, where more than 270 scientists and support personnel pursue research year-round.

MBL hosts scientific meetings, conferences and department retreats, accommodating annually more than 3,500 participants from around the world. MBL's impressive library (MBLWHOI) houses collections for both MBL and nearby Woods Hole Oceanographic Institution.

Current Polar Research

MBL researchers are currently involved in Long-Term Ecological Research projects (LTERs) that are funded by the National Science Foundation. There are 24 LTER sites that have been designated in this NSF program, two of them in Antarctica, one in Alaska, and others in North America and Puerto Rico.

1. Arctic LTER is located in the northern foothills of the Brooks Range, Alaska, a region of diverse vegetation and animals that have adapted to the frigid, dry and windy climate. Present research is focusing on predicting the impact of climate change on plants and animals in the streams and lakes and on the tundra. http://ecosystems.mbl.edu/arc.

2. Antarctic LTER includes two sites, one of which is centered around the area of the U.S. Palmer Station on the west side of the Antarctic Peninsula. MBL's Ecosystems Center involves the study of the marine ecosystem in this part of Antarctica, an area of the continent that has undergone unusual rapid warming in the past decade. [http://pal.lternet.edu.]

Satellite image of Woods Hole and MBL may be found at:

<http://maps.google.com/maps?gl=us&vpsrc=0&ie=UTF8&ll=41.52927,-70.664921&spn=0.028208,0.048151&t=h&z=14>